Indian Institute of Technology
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BCD to 7 segments LED display decoder circuit

Introduction to Electrical and Electronics Circuits

EE 101

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Abstract

In everyday life, we are comfortable in working with numbers (in base 10 i.e., decimal numbers) while machines efficiently work in binary format. To display these numbers different display elements like LCD, LED, 7 segment display, etc. are used. Among these, 7-segment displays are widely used in applications like digital clocks, calculators, speedometers, clock radios, motor-vehicle odometers, etc.

In this project, we will develop a circuit that will convert a BCD coded digit into a base 10 digit and display it through the 7-segment display. With the help of the truth table and k-maps, we will derive the Boolean expression for each of the 7 output signals in terms of input signals. The circuits will be developed using various logic gates like AND, OR, NAND, NOR gates. Finally, the circuit will be implemented using BCD to 7 segment decoder ICs like IC7447 or CD4511.

Keyword

BCD, 7-segment display, Truth Table, K-map, Logic Gates, Decoder ICs, IC7447, CD4511.

Introduction

BCD (Binary Coded Decimal): -

It is a way to represent decimal numbers in which a 4-bit binary code represents the corresponding decimal number. example

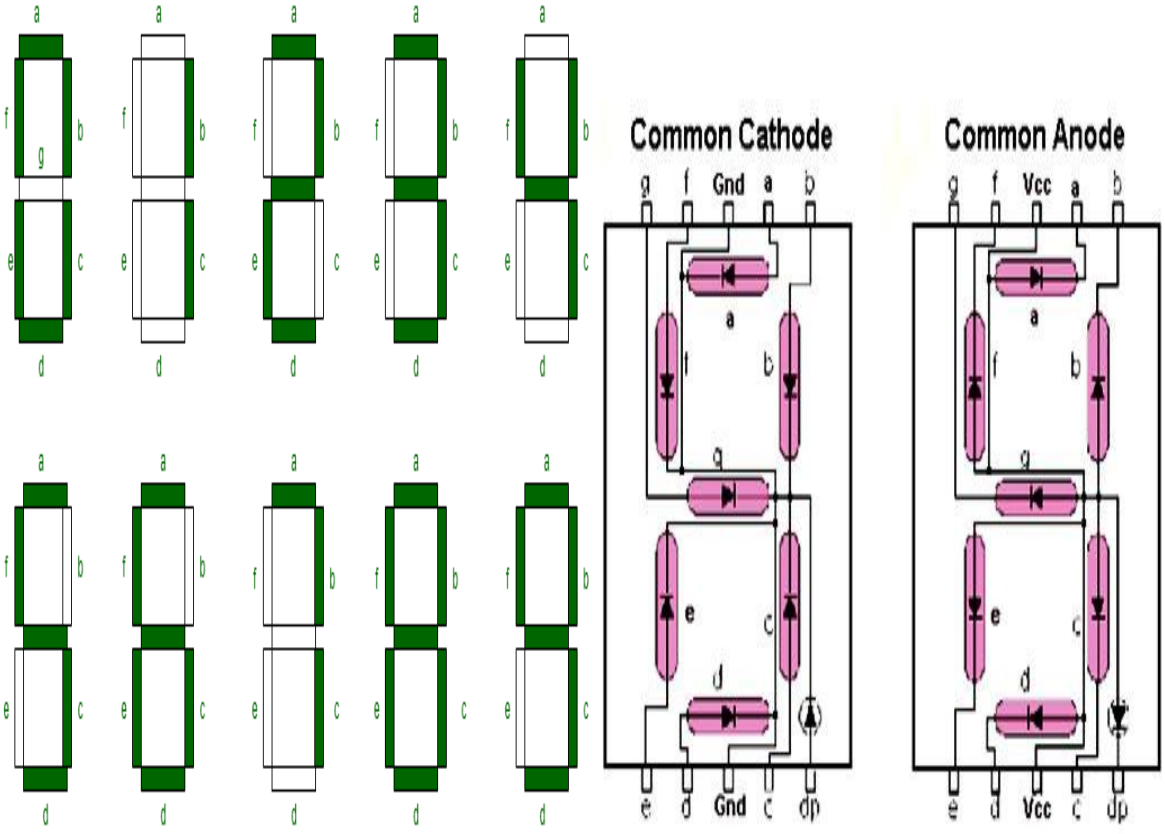
$$(0101)_{BCD} = (5)_{10}$$

$$(1001)_{BCD} = (9)_{10}$$

$$(0101\ 1001)_{BCD} = (59)_{10}$$

7 Segment Display: -

It is an electronic display device equipped with 7 LEDs arranged in a specific pattern (see fig) and 7 pins (a-g) to control these LEDs and with the help of this, we can display any decimal number (0-9) efficiently.

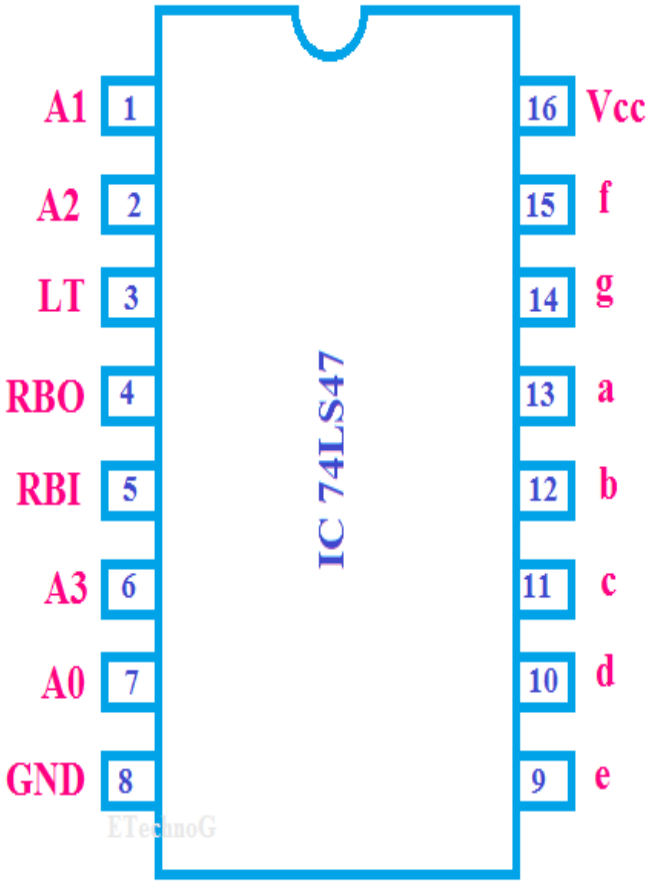


Truth Table: -

It is a tabular representation of all input bits and corresponding all output bits, where 1 represents high or on state and 0 represents low or off state. It helps in then deriving a Boolean expression for all outputs in terms of inputs. See fig. in implementation.

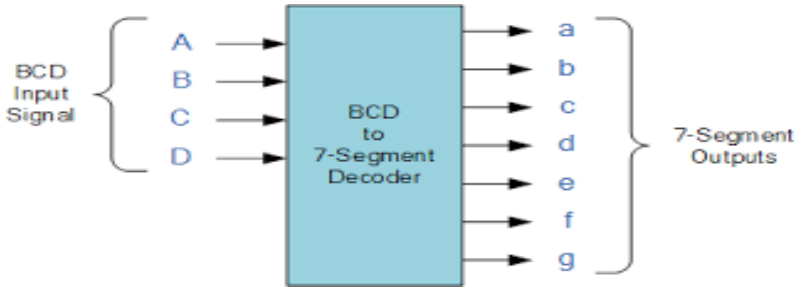
IC 7447/IC 74LS47: -

It is a decoder IC for BCD to 7-segment. It has 4 inputs pin and 7 output pins which are input for the 7-segment display. It has some other pins like V_{cc} and GND for a 5v power supply and grounding. The pin LT is called Lamp Test and it is used for testing purposes when this pin is active high all the output pins should be high otherwise it means that there is some fault in IC.



Implementation

The motive is to develop a relationship between 4-bit BCD input $(DCBA)_{BCD}$ (where A is the least significant bit and D is the most significant bit) to a 7 pin (a-g) output.

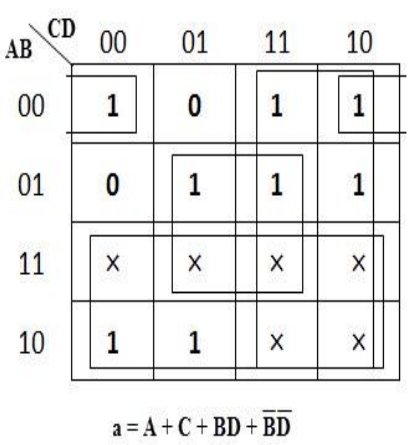


Now truth table for this decoder is: -

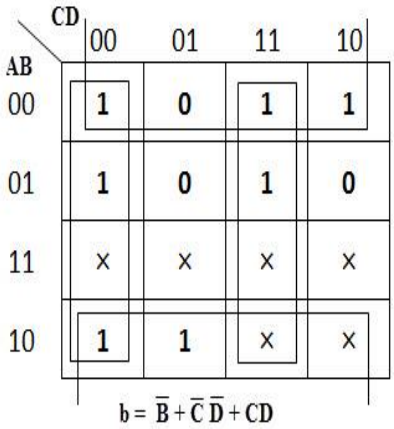
Input Signal (BCD)				Decimal Digit	Output Signal							Output Display
A (LSB)	B	C	D (MSB)		a	b	c	d	e	f	g	
0	0	0	0	0	1	1	1	1	1	1	0	0
1	0	0	0	1	0	1	1	0	0	0	0	1
0	1	0	0	2	1	1	0	1	1	0	1	2
1	1	0	0	3	1	1	1	1	0	0	1	3
0	0	1	0	4	0	1	1	0	0	1	1	4
1	0	1	0	5	1	0	1	1	0	1	1	5
0	1	1	0	6	1	0	1	1	1	1	1	6
1	1	1	0	7	1	1	1	0	0	0	0	7
0	0	0	1	8	1	1	1	1	1	1	1	8
1	0	0	1	9	1	1	1	1	0	1	1	9
0	1	0	1	10	x	x	x	x	x	x	x	X
1	1	0	1	11	x	x	x	x	x	x	x	X
0	0	1	1	12	x	x	x	x	x	x	x	X
1	0	1	1	13	x	x	x	x	x	x	x	X
0	1	1	1	14	x	x	x	x	x	x	x	X
1	1	1	1	15	x	x	x	x	x	x	x	X

Now we will draw a k-map for each of the output signals a-g and from that, we will get the logic expression for each output.

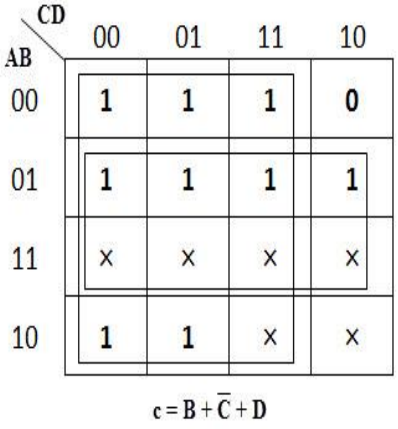
K-Maps: -



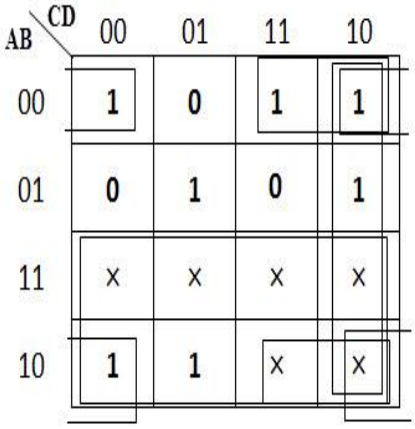
$a = A + C + BD + \overline{B}\,\overline{D}$



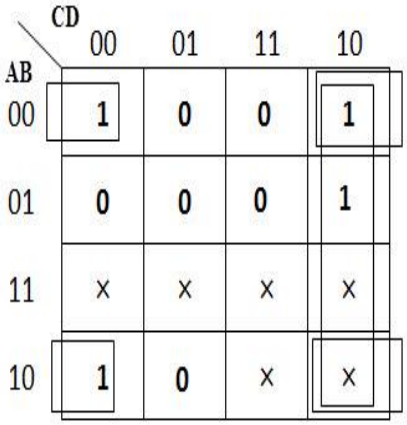
$b = \overline{B} + \overline{C}\,\overline{D} + CD$



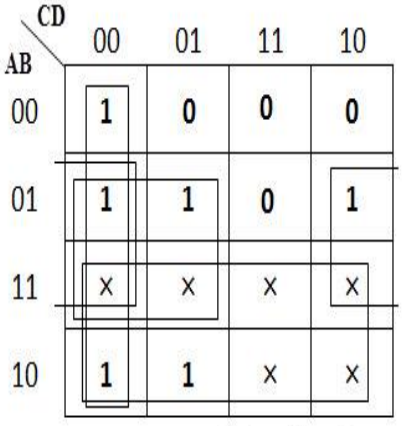
$c = B + \overline{C} + D$



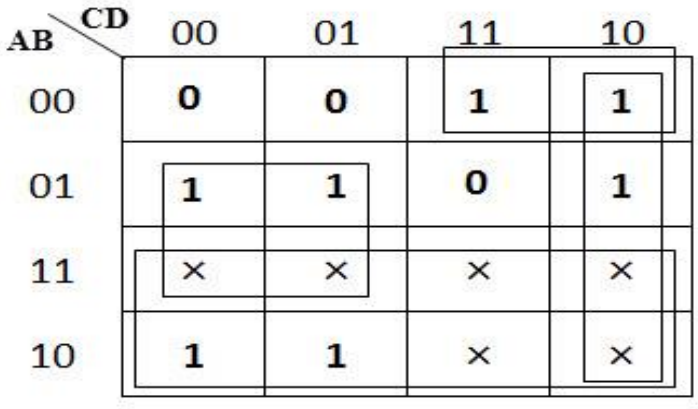
$d = \overline{B}\,\overline{D} + C\,\overline{D} + B\,\overline{C}\,D + \overline{B}\,C + A$



$e = \overline{B}\,\overline{D} + C\,\overline{D}$



$f = A + \overline{C}\,\overline{D} + B\,\overline{C} + B\,\overline{D}$



$g = \overline{B}\,C + C\,\overline{D} + B\,\overline{C} + B\,\overline{C} + A$

So, after solving k-maps we got: -

a = A + C + BD + $\overline{BD}$

b = $\overline{B}$ + $\overline{C}$ $\overline{D}$ +CD

c = B + $\overline{C}$ + D

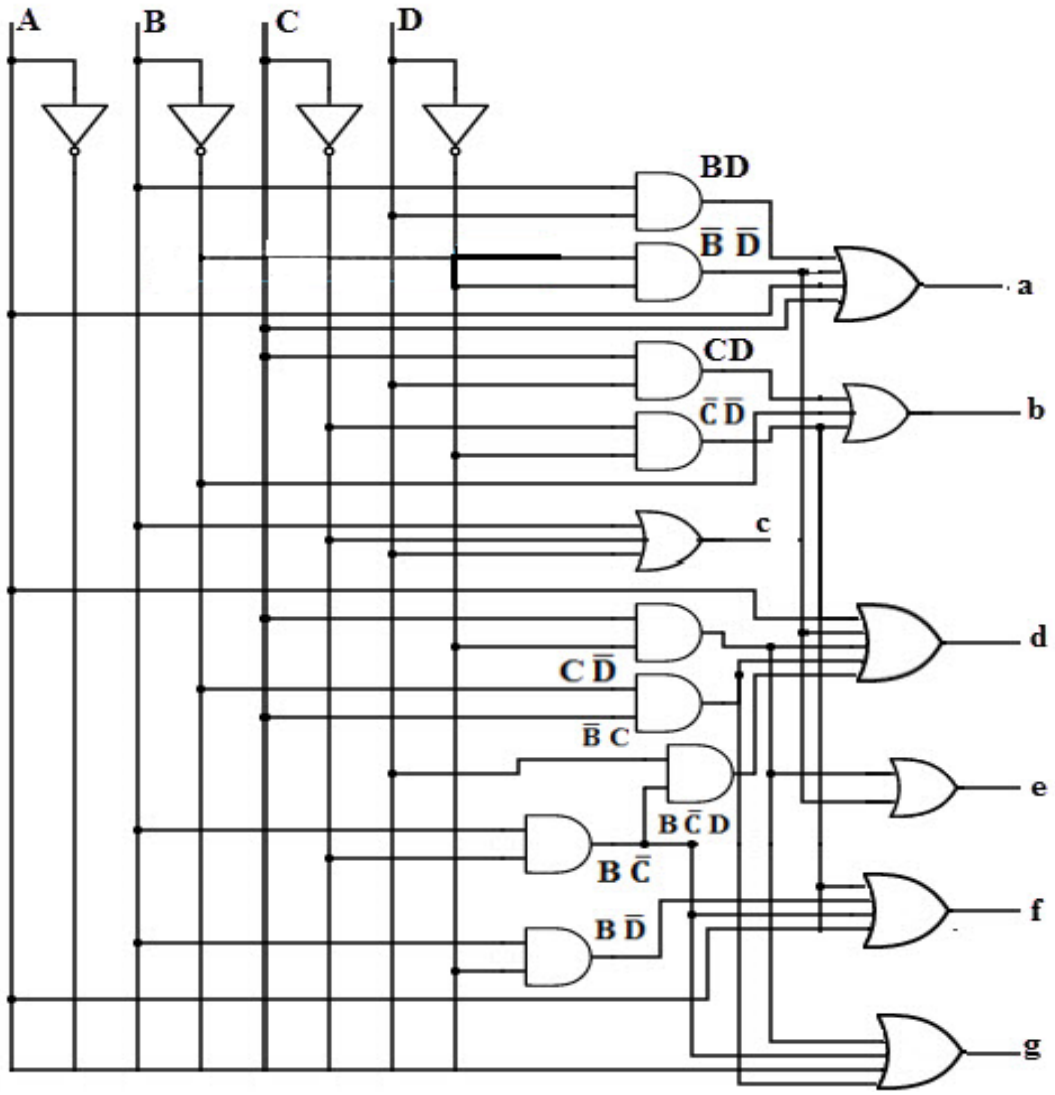
d = $\overline{B}$ $\overline{D}$ + C $\overline{D}$ + B $\overline{C}$ $\overline{D}$ + $\overline{B}$C + A

e = $\overline{B}$ $\overline{D}$ + C $\overline{D}$

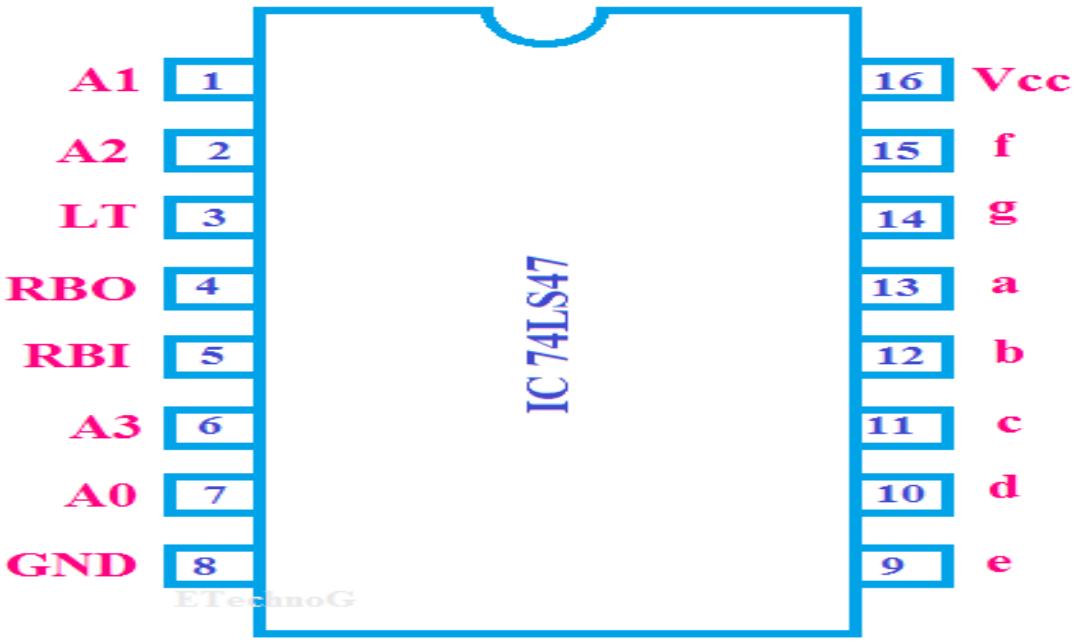
f = A + $\overline{C}$ $\overline{D}$ + B $\overline{C}$ + B $\overline{D}$

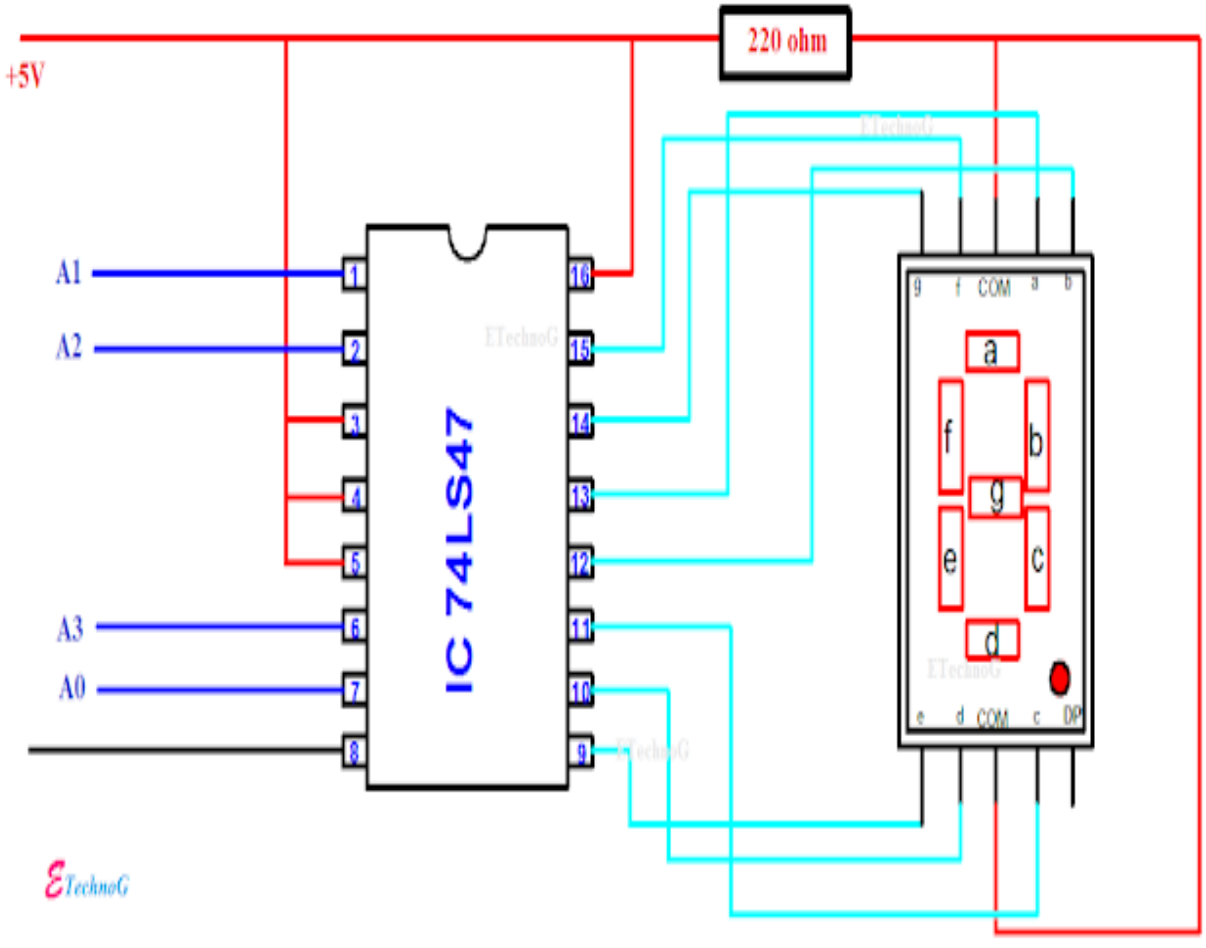
g = A + B $\overline{C}$ + $\overline{B}$C + C $\overline{D}$

now using these relations, we can draw circuit diagram for our decoder.

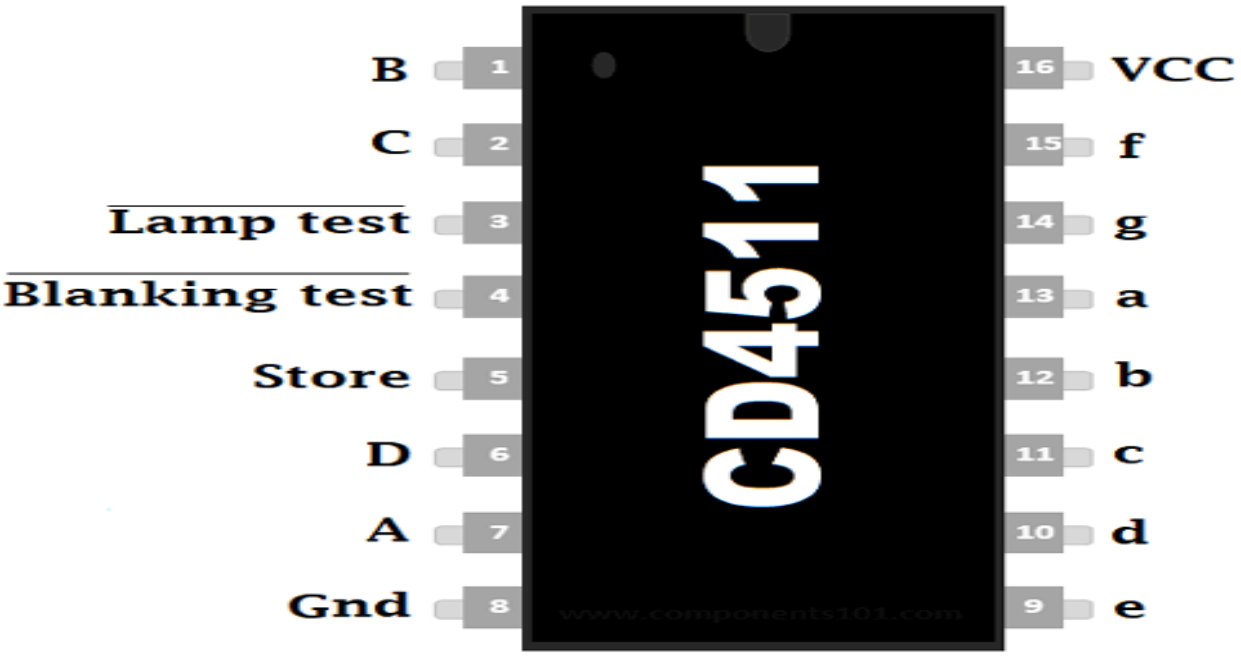


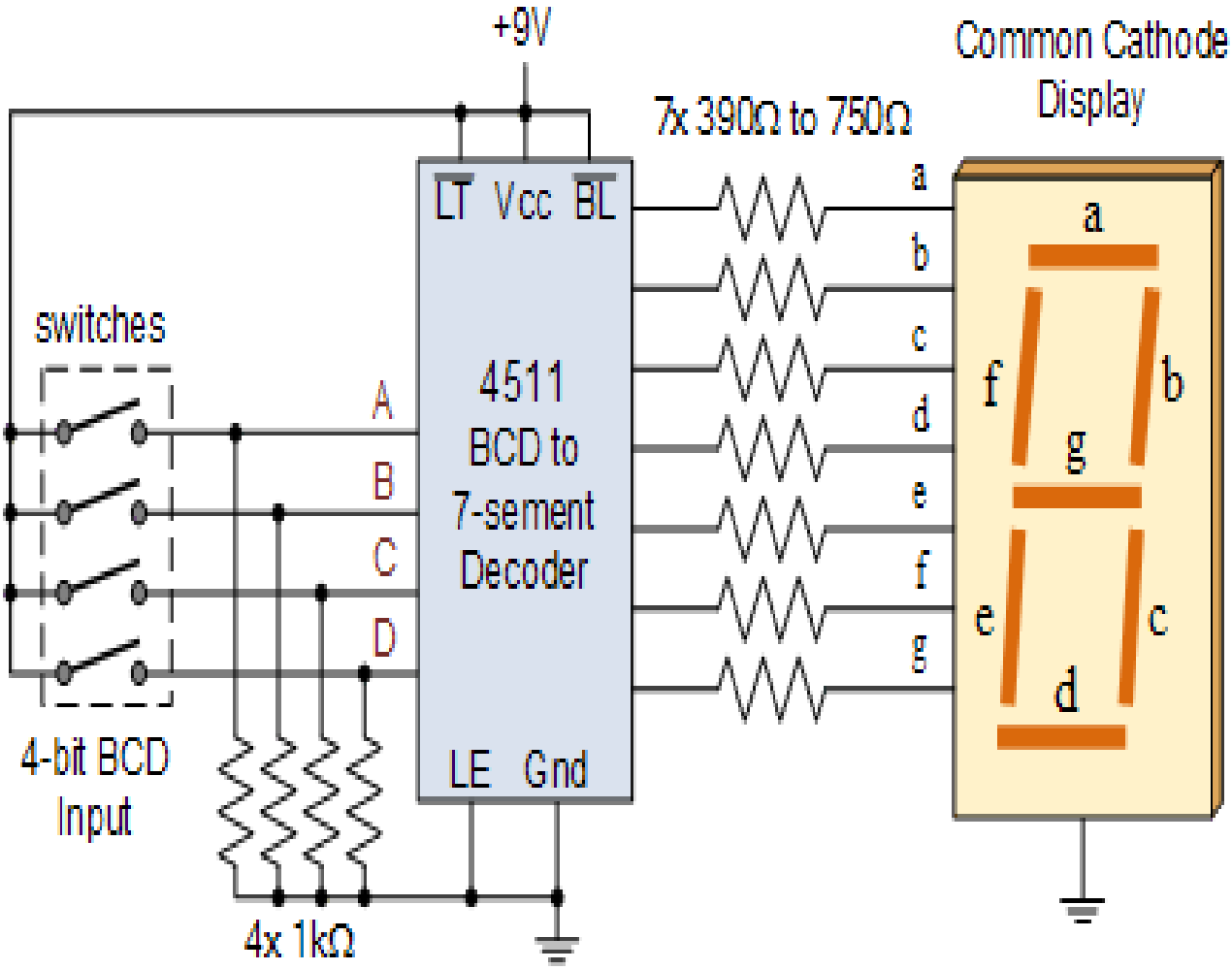
Now Implementing this circuit using IC 7447.





Implementation using IC CD4511





Here is the link where I have virtually implemented this circuit over tinckercad.

Link-> https://www.tinkercad.com/things/6UraSz5SSaw-bcd-to-7-segment-display/editel

Conclusion

A 7-segment display is a very easy and simplest way to represent digital output whereas the circuit might get tricky and involved hence more care should be given during implementation and while deriving the input-output relations using truth table and k-maps. Overall, the project was fun insightful, and experience enriching.

Acknowledgment

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